DESIGN AND CONSTRUCTION OF A SHRIMP HATCHERY FOR THE BREEDING OF THE BLACK TIGER SHRIMP, *Peneaus monodon*

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ABSTRACT

A shrimp hatchery for the breeding of the black tiger shrimp, *Penaeus monodon* was constructed by the Nigeria Institute for Oceanography and Marine Research in 2008 by the reconstruction of an existing old shrimp hatchery. The new shrimp hatchery comprises of the following: water treatment, water storage, broodstock maturation, spawning/incubation, nursery and micro-algae units. The design included the construction of a concrete sump for the collection and treatment of wastewater before disposal, in addition to an aeration unit equipped with root blower for adequate supply of dissolved oxygen. The reconstructed NIOMR shrimp hatchery has been successfully used for the production of post larvae, which are presently being reared to adult shrimp in concrete tanks. The successful completion of the shrimp hatchery and breeding of *P. monodon* has confirmed that the species can be spawned and reared to adult size in Nigeria for local and export markets.

INTRODUCTION

Generally, design is a process of applying engineering knowledge, skills and point of view to the relations, structures, devices and processes according to some standards in order to perform specific tasks. Designs of animal production systems are primarily determined according to the target species, production target, and level of financial input (Platon, 1978, Kato, 1980, Clyde, 1982 and Kungvankij, 1982, 1986) . The designs usually take cognizance of the over-all efficiency of the production system in enhancing growth and survival of target species as well as good management protocols (Tereece and Fox, 1999). Two major hatchery systems are adopted worldwide for animal production especially in fisheries i.e. small-tank hatchery and large-tank hatchery (Mock and Neal, 1974). Major commercial operations adopt the large-tank systems and this may or may not include water recirculation (Kungvankij et al, 1985 and Van-Wyk, 2001). The re-constructed NIOMR shrimp hatchery is a small-tank hatchery targeting the propagation of *P. monodon*. The water holding capacity was estimated based on an approximate ratio between algae culture tanks and larval rearing tanks. The design and reconstruction of NIOMR shrimp hatchery was based on the following design parameters according to Suthep (2008).

Water Reservoir Tank	– 44%
Larvae Tank	– 22%
Water Treatment Tank	– 14%
Algae Tank	– 12%
Broodstock Maturation Tank	– 8%

Total Hatchery Holding Tank Capacity (C_T) = P_y, $R_n P_r$

Where: Py – Production target of PL per year
R_n – production target of PL per cycle
P_r – production rate of PL per m^3
PL – Post Larvae

Estimation of NIOMR Hatchery Total Holding Tank Capacity was based on the following:

Production Target	= 1.26 million PL per year
Production cycle per year	= 7
Duration per cycle	= 40-45 days including tank preparation
Production rate of PL	= 3000 PL / m^3

Data analysis
P_y = 1.26 million PL
R_n = 7
Production target per cycle = 180,000 PL
P_r = 3000 PL/m^3

$C_T = 1{,}260{,}000/21{,}000 = 60m^3$

Based on the total water volume of $60m^3$ for the hatchery, the different components were calculated as follows:

Water Reservoir Tank = 44% of $60m^3$ = $26m^3$
Larvae Tank = 22% of $60m^3$ = $13m^3$
Water Treatment Tank = 14% of $60m^3$ = $8m^3$
Algae Tank = 12% of $60m^3$ = $7m^3$
Broodstock Maturation Tank = 8% of $60m^3$ = $5m^3$

MODIFICATION OF NIOMR OLD SHRIMP HATCHERY

The layout of a shrimp hatchery is a schematic design of the locations and the integration of various facilities such as buildings, tanks, pump house, air supply system and powerhouse required for the production system adopted. Other facilities included were, shrimp laboratory, piping of water and drainage canal. The layout of NIOMR hatchery is presented in Fig.1.

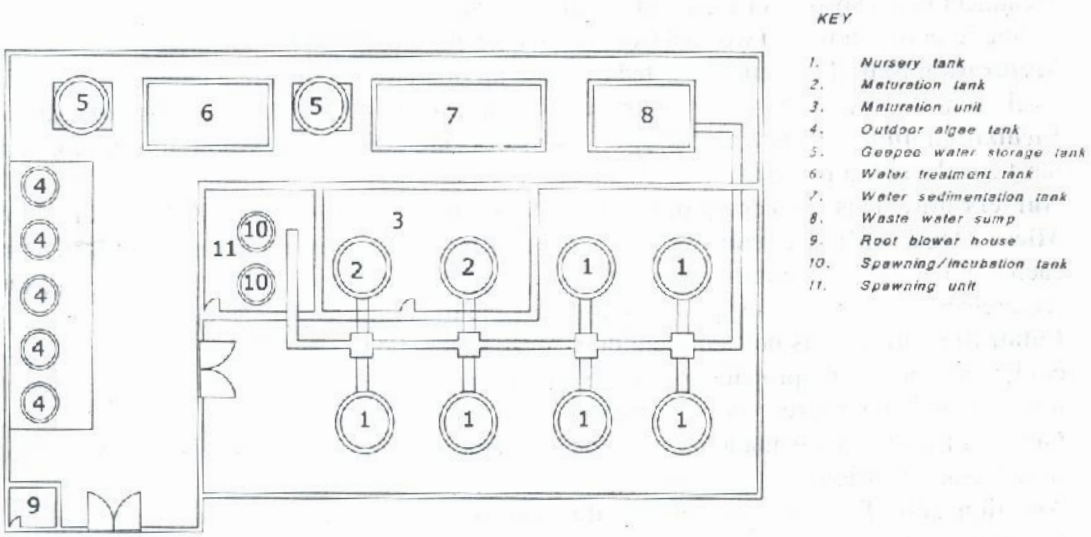

Fig.1 LAYOUT OF NIOMR SHRIMP HATCHERY

The following modifications were made for effective running and operation of NIOMR old hatchery:

- Asbestos roof on the Larvae and maturation tanks were replaced by transparent plastic roof of $25m^2$. This was to allow for 50% light and 50% darkness.
- Larvae and Maturation tanks
- Floors of the tanks were sloped for proper drainage. The drainage pipes were increased from 7.5cm to10.2cm in diameter because of the large volume of waste water that will be discharged.
- Maturation and spawning areas were partitioned with black polythene sheet for effective temperature control and bio-security
- The chambers for harvesting post larvae were made bigger. Grooves for slotting of screens were also constructed to make the harvesting of post larvae easier.
- The PVC pipes supplying seawater to the hatchery were increased from 2.5cm to 5.0cm in diameter.
- The capacity of the waste water sump was increased from 6.0 ton to 9.0 m^3 to accommodate large volume of wastewater for treatment before evacuation.
- Hatchery Wall

- Black polythene sheet was used to cover the outer surface of the wall to effectively control the temperature in the hatchery. Mosquito net was also used as lining on the wall to prevent entry of predators.
- Dips of 50.0cm^2 were constructed at the main entrance of the hatchery and also infront of door to the indoor building. The dips were filled with disinfectant for biosecurity and sanitation of people entering the hatchery.

The construction work was closely supervised and monitored by NIOMR engineers, scientists and FAO shrimp Expert from Thailand to ensure strict adherence to approved design. All the concrete tanks were cast and reinforced with iron rods due to the sandy nature of the soil. The shrimp hatchery was finally commissioned in November 2008. P. *monodon* has been successfully spawned and post larvae produced were stocked in concrete tanks for table shrimp and broodstock production. The hatchery is located at NIOMR Jetty bordering the East-mole of the Lagos harbor.

NIOMR SHRIMP PRODUCTION UNITS

To pioneer the production of shrimp *Penaeus monodom* in Nigeria, Nigeria Institute for Oceanography and Marine Research, Lagos reconstructed her old shrimp hatchery to a modern shrimp hatchery for the spawning of the Africa black tiger shrimp *P.monodon*. The hatchery is made up of the following units:

Water treatment units: This unit involved the sourcing and treatment of sea water. Sea water was sourced from the bar beach using a 4 Hp diesel water pumping machine and six tonnes water tanker. This unit is comprised of the following:

Sedimentation tank (15m^3) - for settling of seawater before treatment.

Treatment tank (8m^3) – for sterilization and chlorination of water.

Plastic reservoir tanks – Two tanks of 7.5 m^3 each for storage of treated water.

Maturation unit: This unit consisted of made up of 2 circular concrete tanks of 3m^{3}each where brood stock from the wild or concrete tanks are acclimatized and kept until final stage of maturation.

Incubation unit: This is where gravid broodstocks are kept for spawning. It is comprised of 4 circular plastic tanks of 0.5 m^3 each.

Nursery unit: This is made up of 6 circular tanks of 3m^3 each for rearing of nauplii to post larvae

Micro- Algae unit: The unit is comprised of an indoor wet lab and 6 outdoor plastic tanks of 1.5 m^3 each for culture the micro-algae *Skeletonema* and *Cheatoceros*. Micro-algae are very vital food requirements for successful spawning and survival of shrimp larval stages.

Laboratory unit: This housed the indoor algae production system. The lab was equipped with major equipment for shrimp propagation (e.g Scope-photo microscope, computer, water distiller, Autoclave, refrigerator, deep freezer, sensitive balance, etc) and chemicals.

Grow-out unit: This is made up of 2 concrete tanks of 10m^3 cubic meters each where post larvae are raised to adult shrimp

Aeration unit: The unit has 2 electrical air blowers piped to all the tanks for constant water aeration and increase in dissolved oxygen content for the sedimentation, treatment, algae, nursery, incubation, maturation and grow-out tanks.

Waste water unit: Waste water from the different units is drained into a concrete Sump of 5m^3 and treated before evacuation.

Power supply unit: The unit has two 5kva generators for constant electricity supply.

OPERATION OF THE SHRIMP HATCHERY

Water Supply

Sea water used in NIOMR hatchery is drawn from the sea through the use of the water tanker and pumped into the sedimentation tank where the suspended solids are allowed to settle down. The top clearer water is pumped into a treatment tank for treatment and chlorination. The treated water was filtered and pumped into an overhead tank and supplied by gravity into various tanks through pvc pipes. Fresh water was sourced from a borehole.

Aeration

Aeration is essential during the entire larval rearing process in maintaining sufficient dissolved concentration in the water and ensuring even water temperature throughout the water column. Two air blowers (3 hp, 1 hp) were interchanged daily to avoid over-heating. The blowers were connected to a main line comprising of 63mm PVC pipe, which were then reduced to 50, 32, 25 and 20mm pipes respectively in order to have good aeration in the entire hatchery and grow-out systems

Temperature regulation

Temperature monitoring and regulation is an important activity in shrimp hatchery operations. Optimum temperature for culture of *P.monodon* ranges from 26-32^{0}C (Parado et al, 1996). Temperatures outside the above range for prolonged periods can stress shrimp and reduce growth. In penaeid shrimp, eggs do not hatch at temperatures lower than 24^{0}C. Larvae usually grow and molt faster at higher temperature (30^{0}C) but do not grow well and molting may be prolonged at lower temperature. Black polythene sheets were used to cover the outside of the hatchery wall to conserve heat in the hatchery and control the temperature. Transparent plastic roofing sheets were also installed for penetration of sunlight.

FACILITY MAINTAINANCE

Shrimp production facilities must be maintained to optimize the conditions for growth, survival and health of the broodstock, larvae and PL, minimizing the risks of disease outbreaks. To prevent the transmission of disease agents from one cycle to the next, the set of Standard Operating Procedures (SOPs) that must be strictly adhered to should be drawn up for personnel including procedures for a sanitary dry out after each production cycle (FAO, 2007). Some of the safety and maintenance measures undertaken included

- Tanks and equipment were thoroughly cleaned on a regular basis and disinfected with Iodine (20-30ppm) before and after use to prevent disease transmission between tanks and cycles. They were later rinsed with abundant clean water to remove effect of iodine and then dried.
- Wearing of protective hand and nose gears while handling the chemicals used for disinfection.
- Regular inspection and servicing of all essential equipment such as generators, water pumps, air blowers and water filtration equipment etc
- Generators were situated away from the air blowers to prevent drawing of air from the exhaust.
- The hatchery design and installation of pipes ensured that plumbing work maintained a proper gradient for easy discharge of water by gravity to avoid stagnation of water in the pipelines which could be a major source of entry of pathogen into the hatchery.
- Air and water pipelines were periodically checked for leakages and repaired if necessary.
- All the filters and filter components such as sand, cartridges, etc were backwashed regularly and the media removed, washed and replaced after every cycle. The sand and other filters were regularly replaced with previously clean and disinfected ones.

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